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(54) CURTAIN COATING

(71) We, CIBA-GEIGY AG, a body corporate organised according to the laws of Switzerland, of Basle, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a curtain coating method and to apparatus for coating travelling web material. The invention is applicable also to the curtain coating of flat objects, such as glass plates carried on a travelling band or chain conveyor.

In one method of producing a coating on web material by the curtain coating process a layer of coating liquid is formed on an inclined slide. The layer of coating liquid flows down the slide and is then allowed to drop off the end of the slide as a free falling curtain. This curtain falls on to a travelling web positioned beneath the inclined slide and is coated thereon as a layer. This method has been extended to cause a plurality of distinct superposed layers of coating liquid to form a multilayer on the inclined slide and to allow this multilayer to fall as a multi-layer free-falling curtain to form a multi-layer coating on the travelling web.

In some applications of curtain coating, it is required to produce thin coatings with a thickness uniformity of the order of 1 per cent. An example is the coating of photographic emulsions on a travelling web of film base. In such cases a severe problem is found in the sensitivity of the thin curtain to ambient air currents.

A curtain fall height of several centimetres is usually necessary to ensure curtain stability and to produce an impact velocity sufficient to ensure good wetting of the film base. The web width is customarily between 1.0 and 1.5 metres and a curtain area of about 0.1m² is therefore presented to any draught which arises in the coating zone. Even a very small pressure difference across such an area will produce a substantial deflection of the curtain. This may seriously reduce the quality of the coating produced. The curtain may thereby be deflected to impinge on the web along a line where instabilities of web position or of air entrainment between curtain and web occur. Alternatively or additionally fluctuations in pressure difference across the curtain can cause the curtain to move to and fro in the direction in which the web is travelling. This causes thickness variations to appear in the coating on the web, even though the thickness of the curtain is itself constant at the line of impact.

There has now been discovered a curtain coating method which is relatively insensitive to the presence of ambient air currents by controlling the position of the curtain during fall so that the line of impact can vary only to a very small extent even in the presence of draughts.

According to the present invention, therefore, there is provided a method of coating an object with a layer of coating composition which comprises the steps of moving the object along a path through a coating zone and forming at the coating zone a falling curtain of the coating composition, providing a descending laminar gas flow between said curtain and a rigid member extending transversely over the path and located adjacent to the coating zone, thereby constraining the curtain to fall in a trajectory following the shape of said rigid member and allowing the falling curtain to impinge on the moving object to deposit thereon a layer of the coating composition.

The method of the invention is of particular use for multilayer curtain coating and thus according to a preferred aspect of the present invention there is provided a method of coating an object with a plurality of layers each layer being of a liquid coating

composition, which comprises the steps of moving the object along a path through a coating zone and forming at the coating zone, from a composite layer comprising a plurality of distinct juxtaposed layer each of liquid coating composition, a falling curtain, providing a descending laminar gas flow between said curtain and a rigid member extending transversely over the path, and located adjacent to the coating zone, thereby constraining the curtain to fall in a trajectory following the shape of said rigid member and allowing the curtain to impinge on the moving object to deposit thereon a composite coating consisting of the plurality of distinct superposed layers.

Thus in the method of the present invention the falling curtain is supported to some extent by the descending laminar gas flow and is thus not a free falling curtain. This gas support renders the falling curtain more stable in an air current.

In one aspect of the invention there is provided a method of coating an object with a layer of coating composition which comprises the steps of moving the object along a path through a coating zone and forming at the coating zone a falling curtain of the coating composition, providing a descending laminar air flow between said curtain and a rigid member having a convex profile on the underside extending transversely over the path and located adjacent to the coating zone, thereby constraining the curtain to fall in a trajectory following the curve of the convex profile of the said rigid member, and allowing the curtain to impinge on the moving object to deposit thereon a layer of the coating composition.

The method of the invention is of particular use for multilayer curtain coating and thus according to a preferred aspect of the present invention there is provided a method of coating an object with a plurality of layers each layer being of a liquid coating composition, which comprises the steps of moving the object along a path through a coating zone and forming at the coating zone, from a composite layer comprising a plurality of distinct juxtaposed layers each of liquid coating composition, a falling curtain, providing a descending laminar air flow between said curtain and a rigid member having a convex profile on the underside extending transversely over the path, and located adjacent to the coating zone, thereby constraining the curtain to fall in a trajectory following the curve of the convex profile of the said rigid member, and allowing the curtain to impinge on the moving object to deposit thereon a composite coating consisting of the plurality of distinct superposed layers.

The rigid member may be located in front of the curtain (as shown in Figure 1) or behind the curtain that is to say between the falling curtain and the support part of the coating head (as shown in Figure 2). Preferably in either position it is located downstream with regard to the movement of the object being coated in relation to the curtain (as shown in Figures 1 and 2). The descending laminar gas flow may be produced by discharging gas through a downwardly facing slot adjacent to the rigid member.

In one aspect of the invention the rigid member may have a very curved profile for example a round bar. In such case the rigid member is so located that the laminar gas flow passes partly below the rigid member, that is to say the profile of the curved member as presented to the falling curtain is in the nature of a convex overhang. On the other hand the rigid member may not present such a curved profile and in fact may present a straight face or almost straight face to the falling curtain. In this case the straight face may be vertical or set at an angle for example 10° out of vertical. Preferably the upper part of the rigid member is placed within a few millimetres of the line of the free fall of the curtain. When the laminar gas flow is produced the free falling curtain moves towards the rigid member and follows a path closely following the profile of the rigid member as presented to it, but separated from the rigid member by the laminar gas flow.

Thus in the method of the present invention a free-falling curtain is not produced because the curtain is supported to some extent by the laminar gas flow. The amount of support depends on the flow of gas and on the shape of the rigid member.

Preferably the gas used in the method of the present invention is air. The method of the present invention is of particular use in the coating of a plurality of photographic layers on a travelling web such as film or paper.

Preferably each layer is formed by continuously metering each of the coating compositions through a respective elongate slot onto an inclined slide surface. The elongate slots emerge on to the slide surface one above the other in substantially coplanar relation. The lowermost end of the slide surface terminates in a lip. Coating composition which issues from each slot flows down the slide to form a layer on the slide surface, each layer other than that formed from the coating composition which issues from the lowermost slot flows into superimposed surface contact with the top of the layer of coating composition which issues from the slot placed therebelow. Thus a composite layer is formed which is directed over the lip to form a curtain which falls following the shape of the rigid member.

According to another aspect of the invention there is provided an apparatus for coating an object with a layer of a liquid coating composition, comprising means for moving an object to be coated along a path through a coating zone, and coating means spaced vertically above the path, the coating means comprising means for forming, at the coating zone, a falling curtain of coating liquid, a rigid member extending transversely over the path and means for providing a descending laminar gas flow over said rigid member, said member being so placed to cause said curtain to follow its shape before impinging on the moving object.

In another embodiment of this invention there is provided an apparatus for coating an object with a plurality of layers each layer being of a liquid coating composition, comprising means for moving an object to be coated along a path through a coating zone, and coating means spaced vertically above the path, the coating means comprising means for forming a composite layer comprising a plurality of distinct juxtaposed layers each of liquid coating composition, means for forming, from the composite layer, at the coating zone, a falling curtain, a rigid member extending transversely over the path and means for providing a descending laminar gas flow over said rigid member, said member being so placed to cause said curtain to follow its shape before impinging on the moving object.

Preferably in this embodiment of the invention there is provided an inclined slide surface, elongate slots emerge on to the slide surface one above the other in substantially co-planar relation and the lowest end of the slide surface terminates in a lip. A composite layer is formed when coating liquid issues from each slot in the inclined slide and falls down the slide, the liquid from the topmost slot sliding over the liquid issuing from the next-to-topmost slot and so on.

In one embodiment of the invention there is provided an apparatus for coating an object with a layer of a liquid coating composition, comprising means for moving an object to be coated along a path through a coating zone, and coating means spaced vertically above the path, the coating means comprising means for forming, at the coating zone, a falling curtain of coating liquid, a rigid member extending transversely over the path and having a convex profile on the underside, and means for providing a descending laminar air flow over said curved profile, said member being so placed to cause said curtain to follow a curved trajectory before impinging on the moving object.

In another embodiment of this invention there is provided an apparatus for coating an object with a plurality of layers each layer being of a liquid coating composition, comprising means for moving an object to be coated along a path through a coating zone, and coating means spaced vertically above the path, the coating means comprising means for forming a composite layer comprising a plurality of distinct juxtaposed layers each of liquid coating composition, means for forming, from the composite layer, at the coating zone, a falling curtain, a rigid member extending transversely over the path and having a convex profile on the underside, and means for providing a descending laminar air flow over said curved profile, said member being so placed to cause said curtain to follow a curved trajectory before impinging on the moving object.

Preferably in the method and apparatus of the present invention the object to be coated is a travelling web and preferably the falling curtain impinges on the web where the web is supported by a roller. In a particular embodiment of the invention, the web may be lapped around a roller which both supports the web and assures uniformity of web speed. Preferably the coating means for forming a composite layer comprising a plurality of distinct juxtaposed layers is an inclined slide hopper having across its surface a plurality of coating slots from which the coating compositions issue. Such an inclined slide hopper is shown in Figure 1 of British Patent Specification No. 1,276,381:

The method and apparatus of the present invention are preferably employed to coat a plurality of photographic layers including at least one aqueous colloid silver halide emulsion layer on a travelling film or paper web.

The rigid member may be a bar which extends transversely over the path of the travelling web and located close to the supported falling curtain. The bar may be of uniform cross-section presenting either a curved or a flat surface to the descending laminar air flow. The bar may be of metal, glass or plastics material. Preferably when the coating device used is a slide hopper which has an overhanging lip the shaped rigid member is located beneath the overhanging lip and may be integral with the slide hopper.

In the apparatus of the invention preferably the gas used is air and means are provided for producing a descending laminar air flow.

The accompanying drawings, which in no way limit either the method of the invention or the apparatus of the invention, serve to illustrate the method of the invention and apparatus by which this method may be carried out.

Figure 1 is a diagrammatic side elevation of a coating apparatus according to the present invention, the rigid member being placed in front of the falling curtain.

Figure 2 is a diagrammatic side elevation of a coating apparatus according to the present invention the rigid member being placed behind the falling curtain.

Figure 3 is a perspective view of the apparatus of Figure 2 showing the location of the various parts of the apparatus.

Figure 4 is a diagrammatic side elevation of another coating apparatus according to the present invention which is similar to that of Figs. 2 and 3 but which has a rigid member with a substantially straight edge.

Figure 5 shows in detail an air slot different to that shown in Figures 2—4 but which could be used in the apparatus shown in these Figures.

In the Figure 1 a slide hopper 1 is located above a web supporting roller 2 which causes a web 3 of film material to pass below the lip 4 of the hopper 1. The slide hopper has an inclined surface 5.

The hopper 1 has located across its surface two slots 6 and 7. Out of slot 6 is shown issuing coating composition 8. This forms a flowing layer on the inclined surface 5 of the hopper 1. Out of slot 7 is shown issuing coating composition 9. This forms a flowing layer on the inclined surface 5 and then flows over the layer of coating composition 8 to form a composite layer. This composite layer flows down the inclined surface 5 until it reaches the lip 4 of the slide hopper and then it falls as a multi-layer curtain 10.

Positioned close to the end of the lip 4 is a curved rigid member 12 and located close to the top of the rigid member 12 is a baffle 13. Air is forced between the member 12 and the baffle 13 and forms a descending laminar air flow between the member 12 and the curtain 10. This causes the curtain 10 to be attracted towards but spaced from the rigid member 12 and to follow a curved trajectory until it falls on to the travelling web 3 and is carried along thereon as composite coated layer 15.

The curtain 10 is stable and is relatively unaffected by ambient air currents.

In an alternative embodiment baffle 13 is not used, a descending laminar air flow being caused to pass between the member 12 and the lip 4 of the hopper 1.

In Figure 2 a slide hopper 21 is located above a coating roller 22 which when it rotates causes a web 23 of film material to pass below the lip 25 of the hopper 21. The slide hopper has an inclined surface 26.

The hopper 21 has located across its surface two slots 27 and 28. Out of slot 27 is shown issuing coating composition 29. This forms a flowing layer on the inclined surface 26 of the hopper 21. Out of slot 28 is shown issuing coating composition 30. This forms a flowing layer on the inclined surface 26 and then flows over the layer of coating composition 29 to form a composite layer. This composite layer flows down the inclined surface 26 until it reaches the lip 25 of the slide hopper 21 and then it falls as a multi-layer curtain 31.

Positioned under the lip 25 is an air duct 32 which has a downward facing nozzle 33. This is shown more clearly in Figure 3 in which the numbers have the same signification as in Figure 2. Attached to the side of the air duct 32 and falling in a curved profile below the air duct is a curved rigid member 34.

Also shown is one of a pair of edge guides 35. An edge guide is fitted to each edge of the slide hopper 21 and when the apparatus is in operation the edge guides determine the width of the falling curtain.

Also shown is a catch plate 36 which is used to catch the vertical falling curtain at the start-up and close-down of a coating operation.

In operation a falling multi-layer curtain 31 is formed. Initially this falls as free-falling curtain from the lip 25 of the slide hopper 21. Then air from the duct 32 is caused to issue from the nozzle 33. This causes a laminar air flow to be formed between the rigid member 34 and the falling curtain 31.

This sucks the falling curtain towards the surface of the rigid member 34 so that the falling curtain 31 falls in a curved trajectory following the shape of the rigid member 34. This is shown in Figure 2. The falling curtain 31 is deposited on the travelling web 23 and is taken away as a composite coated layer 38.

It has been found that the falling curtain 31 when it has curved trajectory following the shape of the rigid member 34 is extremely stable and relatively unaffected by air currents.

In one experiment using gelatin having a viscosity of 15 cp and a flow rate of 2 ml/per second per centimetre width, the horizontal displacement resulting from a specified air draught of short duration was measured for both a free falling curtain and a curtain supported by descending laminar air flow as just described.

For the free falling curtain the average horizontal displacement 80 mm below the lip 25 produced by the draught was 7 mm whilst in the case of the air supported curtain using an air jet gap of 0.6 mm and an air velocity at the jet of 6m/sec the average horizontal displacement 80 mm below the lip was 3 mm.

Figure 4 shows a similar apparatus in which the numbers have the same significa-

tion as in Figure 2 and 3. However in the case of this apparatus the rigid member 34a presents a substantially straight edge to the falling curtain 31. The straight edge of the member 34a as presented to the falling curtain is inclined from the vertical at 10°. The falling curtain is shown to follow the shape of the rigid member down to the end of the straight edge. In this case also an extremely stable curtain was formed which was relatively unaffected by air currents.

In one experiment the height of the falling curtain 31 was 80 mm. The air jet gap was 0.6 mm and air issued from the nozzle 33 with a velocity of 5m/sec. This was sufficient to suck the falling curtain, having a flow of 1.5 mls/cm/sec, towards the rigid member 34 so that it was spaced apart from the rigid member throughout its length by approx 3 mm.

In this method an additional advantage may be gained when the gap between the lower edge of the rigid member and the web, moving in this case from left to right as shown in the Figure 4 is reduced so as to restrict the escape of the airflow.

A positive gas pressure is thereby created in the region of the impact zone of the curtain on the web on the side of the curtain adjacent to the rigid members.

This tends to oppose the forces imposed on the impact zone by air entrained by the moving web thus allowing high coating quality to be maintained at higher web speeds than are possible using a free falling curtain.

In Figure 5 there is shown an air duct 32 which has been placed directly under the lip 25 of a slide hopper 21. In this case the extremity of the tip of the slide hopper forms part of the nozzle 33.

WHAT WE CLAIM IS:—

1. A method of coating an object with a layer of coating composition which comprises the steps of moving the object along a path through a coating zone and forming at the coating zone a falling curtain of the coating composition, providing a descending laminar gas flow between said curtain and a rigid member extending transversely over the path and located adjacent to the coating zone, thereby constraining the curtain to fall in a trajectory following the shape of said rigid member and allowing the falling curtain to impinge on the moving object to deposit thereon a layer of the coating composition.

2. A method according to claim 1 wherein the object is coated with a plurality of layers each layer being of a liquid coating composition which comprises the steps of moving the object along a path through a coating zone and forming at the coating zone, from a composite layer comprising a plurality of distinct juxtaposed layers each of liquid coating composition, a falling curtain, providing a descending laminar gas flow between said curtain and a rigid member extending transversely over the path, and located adjacent to the coating zone, thereby constraining the curtain to fall in a trajectory following the shape of said rigid member and allowing the curtain to impinge on the moving object to deposit thereon a composite coating consisting of the plurality of distinct superposed layers.

3. A method according to claim 1 wherein the rigid member has a convex profile on the underside and the falling curtain falls in a trajectory following the curve of the convex profile of the rigid member.

4. A method according to claim 2 wherein the rigid member has a convex profile on the underside and the falling curtain falls in a trajectory following the curve of the convex profile of the rigid member.

5. A method according to any one of claims 1 to 4 wherein the rigid member is located in front of the falling curtain.

6. A method according to any one of claims 1 to 4 wherein the rigid member is located behind the falling curtain.

7. A method according to any one of claims 1 to 6 wherein the rigid member is a bar.

7. A method according to any one of claims 1, 2, 5 and 6 wherein the rigid member presents a straight or almost straight edge to the falling curtain.

9. A method according to any one of claims 1, 2, and 5 to 8 wherein the gas used is air.

10. A method according to any one of claims 1 to 9 wherein the object being coated is a travelling web.

11. A method according to any one of claims 1 to 10 wherein the coating composition is or includes at least one silver halide emulsion.

12. Photographic silver halide material which has been prepared by the method of claim 11.

13. A method of coating an object with a layer of coating composition according to claim 1 substantially as hereinbefore described with reference to the accompanying drawings.

14. An apparatus for coating an object with a layer of a liquid coating composition, comprising means for moving an object to be coated along a path through a coating zone, and coating means spaced vertically above the path, the coating means comprising means for forming, at the coating zone, a falling curtain of coating liquid, a rigid member extending transversely over the path and means for providing a descending laminar gas flow over said rigid member, said member being so placed to cause said cur-

tain to follow its shape before impinging on the moving object.

15. An apparatus for coating an object with a plurality of layers each layer being of a liquid coating composition, comprising means for moving an object to be coated along a path through a coating zone, and coating means spaced vertically above the path, the coating means comprising means for forming a composite layer comprising a plurality of distinct juxtaposed layers each of liquid coating composition, means for forming, from the composite layer, at the coating zone, a falling curtain, a rigid member extending transversely over the path and means for providing a descending laminar gas flow over said rigid member, said member being so placed to cause said curtain to follow its shape before impinging on the moving object.

16. An apparatus according to claim 15 wherein the coating means comprises an inclined slide surface, elongate slots emerge on to the slide surface one above the other in substantially co-planar relation and the lowest end of the slide surface terminates in a lip.

17. An apparatus according to any one of claims 14 to 16 wherein the rigid member has a convex profile on the underside.

18. An apparatus according to any one of claims 14 to 17 wherein the gas provided is air.

19. An apparatus according to any one of claims 14 to 18 wherein the object to be coated is a web supported by a roller.

20. An apparatus according to any one of claims 14 to 19 wherein the rigid member is a bar.

21. An apparatus according to any one of claims 14 to 16 wherein the coating device is a slide hopper which has an overhanging lip and the shaped rigid member is located beneath the overhanging lip.

22. An apparatus according to claim 21 wherein in operation the shaped rigid member presents a straight or almost straight edge to the falling curtain.

23. An apparatus according to claim 22 wherein the straight edge is set at an angle out of the vertical.

24. An apparatus for coating an object with a layer of coating composition substantially as hereinbefore described with reference to the accompanying drawings.

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4 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 1

FIG. 1.

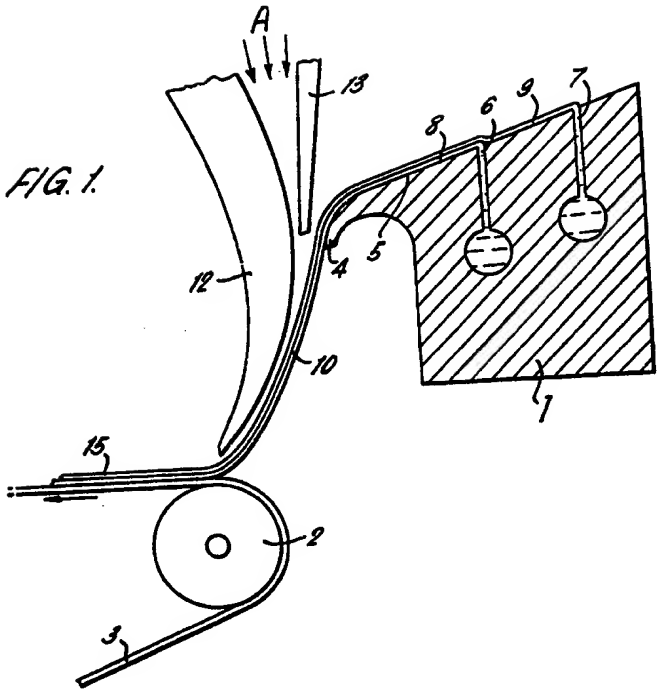

FIG. 5.

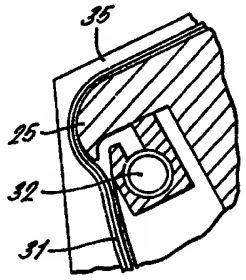

FIG. 2.

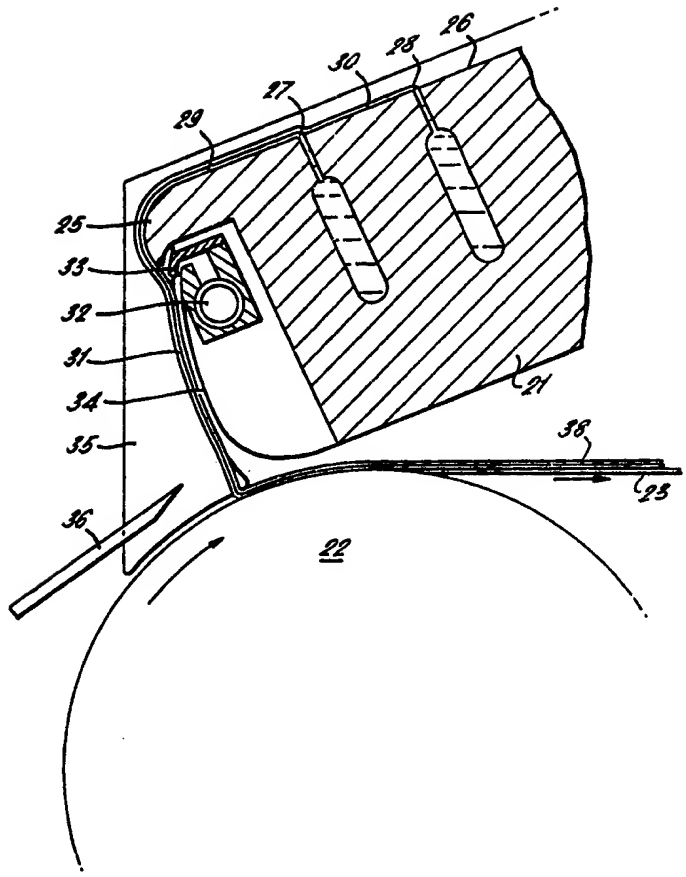

FIG. 3.

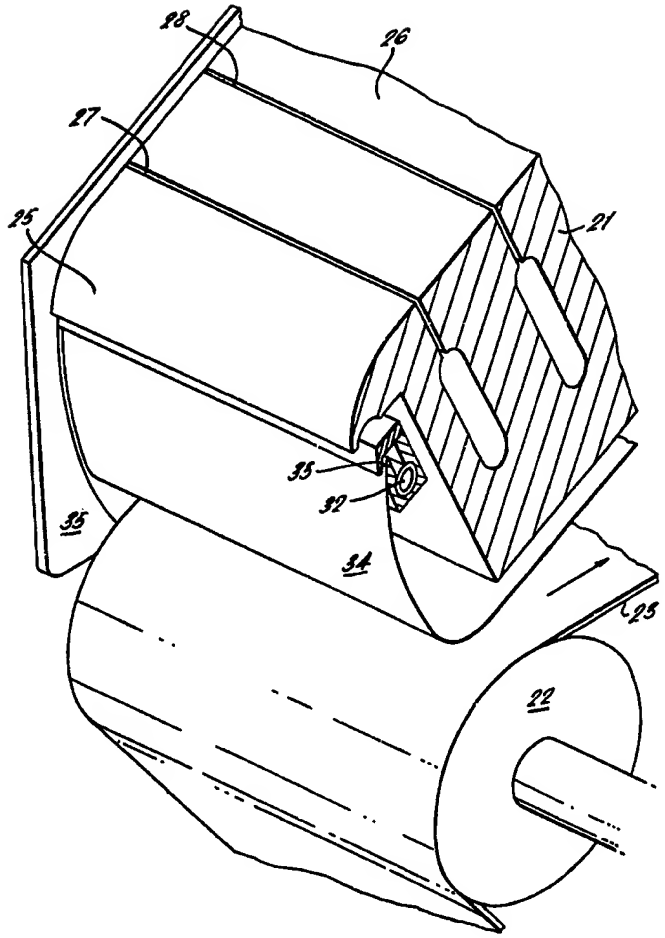

FIG. 4.